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OPERATING EXPERIENCE
WEEKLY SUMMARY

Office of Nuclear and Facility Safety

March 19 - March 25, 1999

Summary 99-12

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EVENTS

1. FAILED PRESSURE INDICATOR LEADS TO HYDROGEN CYLINDER RUPTURE

On March 11, 1999, at the Savannah River Laboratory Technical Area Fracture Toughness Test Facility (FTTF), a half-liter hydrogen cylinder became overpressurized and ruptured as personnel were filling it using an air-operated positive displacement pump. The force of the rupture was contained inside a concrete-and-steel test vault that is designed to perform destructive testing in a hydrogen environment. The occurrence did not cause personnel injury or facility damage, but it is significant because the release of an overfilled hydrogen cylinder for use in the laboratory could pose a serious threat to personnel or equipment. (ORPS Report SR--WSRC-LTA-1999-0011)

The FTTF is normally used for high-pressure experimentation and fracture studies of material samples, pressure vessels, and other components. It contains equipment capable of delivering pressures up to 30,000 psi. As a service to laboratory scientists, FTTF personnel occasionally use the facility to refill laboratory-size helium or hydrogen cylinders (lecture bottles). The cylinder that ruptured was rated for approximately 1,800 psi and was being filled to a target pressure of 1,700 psi. Facility personnel report that the failure occurred at an indicated pressure of approximately 1,500 psi. Figure 1-1 shows the failed gas cylinder.

Figure 1-1. Failed Gas Cylinder

Following a critique of the occurrence, facility personnel examined all of the cylinders on hand and determined that they were either empty or filled to the correct pressure. The facility manager ordered an investigation of the occurrence and immediately suspended all further pressurizations in the FTTF facility until corrective actions have been identified and implemented. Investigators determined that the only indication of fill pressure immediately available to FTTF operators during this operation is a digital pressure meter at a control station outside the test vault. Examination of this instrument showed that it had failed, and that actual pressure could have been more than five times the indicated pressure. Investigators also determined the following.

- Although the FTTF high-pressure manifold has rupture disk protection, the rupture disk was not adequately sized to provide protection for this type of cylinder. Thus, the failed digital pressure instrument was the single barrier to overpressurizing a cylinder.

- FTTF procedures require operability and calibration tests of pressure instrumentation in conjunction with test plans but do not require them before filling lecture bottles.

- FTTF personnel had not identified the need for a process hazards review for filling lecture bottles.

The FTTF manager has directed personnel to complete a system operating design review for the process of filling gas cylinders. During the critique of this occurrence, facility personnel identified the following corrective actions to establish defense-in-depth for cylinder filling operations.

- Establish a calibration procedure and frequency for the failed pressure instrument.

- Evaluate the need to install additional pressure relief capability.

- Perform a failure analysis of the digital pressure readout.

- Establish a filling operations log that identifies end-users.

- Evaluate the need to conduct a job hazard analysis for filling operations.

- Evaluate the need to establish shelf life and service test protocols for the gas cylinders.

This occurrence at Savannah River underscores the importance of completing a hazard analysis for each different process. Nonsafety-related systems or equipment may be used for purposes other than their primary purpose, so long as potential hazards are identified and engineering and administrative controls are applied to eliminate or minimize them. The filling of lecture bottles seemed to fall within the safety envelope previously established for high-pressure testing; however, the rupture of a cylinder revealed an unanticipated potential to release an overfilled gas cylinder to laboratory personnel.

Facility managers should ensure that each existing, new, or modified process at their facilities has been analyzed and managed in accordance with the core functions of DOE G 450.4-1, *Integrated Safety Management System Guide*. These core functions are as follows: define the scope of work, analyze hazards, develop and implement controls, perform work in accordance with controls, and integrate feedback and improvement. The guide states that the core functions, along with guiding principles, apply to the planning and performance of all types of potentially hazardous work, including construction, operation, and decommissioning. Chapter II, section 3, “Analyze Hazards,” states that two analysis methods used by industry to evaluate hazards are process hazard analysis and job hazard analysis. Information on the application of these analysis methods is available in DOE O 440.1, *Worker Protection Management for DOE Federal and Contractor Employees*, and OSHA Standard 29 CFR 1910.119, *Process Safety Management (PSM) of Highly Hazardous Chemicals*. Although the OSHA standard is specific to hazardous and explosive chemical processes, the principles it contains can be applied to safety management for any potentially hazardous process.

KEYWORDS: cylinder, hazard analysis, rupture

FUNCTIONAL AREAS: Hazards and Barrier Analysis, Operations

2. BATTERY EXPLODES

On March 8, 1999, at the Idaho National Engineering Environmental Laboratory Central Facilities Area, a utility operator was starting a diesel-driven fire water pump for a weekly test run when one of the associated batteries exploded. He was approximately 20 feet away when the battery exploded and spilled approximately 1 quart of acid on the concrete floor. The operator was not injured, so he secured the evolution and notified the appropriate supervisor of the explosion. A protective plastic covering over the battery bank was damaged when the battery exploded, as seen in Figure 2-1. No one had performed any inspection or surveillance of the facility fire water batteries since September 1997. Failure to perform inspections or surveillances on equipment that is required to be operable as part of the facility safety basis could violate the operational safety and technical safety requirements, which represent the minimum acceptable controls necessary to ensure safe facility operation. (ORPS Report ID--LITC-CFA-1999-0003)

Figure 2-1. Battery Bank and Damaged Plastic Cover after Explosion

Investigators determined that the preventive maintenance program required personnel to perform weekly inspections of the batteries. In September 1997, a work control group attempted to change the way the fire water batteries preventive maintenance was being completed and notified maintenance personnel (who were then performing the battery inspections) of the change. Because of a miscommunication, maintenance personnel believed that they were no longer responsible for performing the battery inspections and that another group would perform any future inspections.

The facility manager held a critique of this event. Critique members learned the following.

- The electrolyte in the battery that exploded was low.
- The bus bar in the battery that exploded was fractured and some corrosion was found in the break area.
- The facility fire water pump batteries are 5 years old.

Facility personnel contacted the battery manufacturer and discussed the event. They believe that low electrolyte contributed to the lead corrosion and that the corrosion led to volume expansion inside the battery, causing the bus bar to experience unexpected mechanical forces and to fracture. They also believe that the arc and the cell case rupture occurred when the operator attempted to start the pump, because of the fractured bus bar. In addition, some manufacturers recommend replacing these types of lead-acid batteries every 5 years. The facility manager directed facility personnel to switch to nonleaded acid batteries.

NFS has reported numerous events in which surveillances or inspections were not performed at the required frequency. Some examples follow.

- Weekly Summary 98-05 reviewed two events involving a failure to conduct surveillances and inspections. In one event, facility personnel at the Hanford Tank Farm discovered that functional tests for the high-efficiency particulate air filter differential pressure interlocks and the stack high radiation alarm were not current because no one entered facility safety documentation changes into the computerized planned maintenance system used to schedule surveillances. In the other event, fire protection personnel at the East Tennessee Technology Park discovered that the computerized fire inspections management information system failed to schedule several monthly fire department walk-downs, monthly sprinkler system inspections, semiannual alarm tests, main drain tests, and annual fire extinguisher inspections. (ORPS Reports RL--PHMC-TANKFARM-1998-0010 and ORO--LMES-K25GENLAN-1998-0003)
- Weekly Summaries 97-17 and 97-15 reported missed surveillances at the Oak Ridge Radiochemistry Engineering Development Center. In one event, inspectors failed to perform an efficiency test on high-efficiency particulate air filters for 18 months because a hold tag had not been removed after mechanics replaced the filters. In the other event, fire department personnel did not perform monthly inspections because of an informal policy for establishing inspection frequencies. (ORPS Reports ORO--ORNL-X10REDC-1997-0003 and 0002)

These events illustrate the importance of properly tracking, scheduling, and conducting surveillance tests and inspections. It is important to implement adequate administrative controls that could affect safety-related systems and components to ensure any changes are independently verified and communicated to the responsible personnel. Surveillances must be carried out correctly to guarantee the correct functioning of required operational safety systems. Guidance on battery surveillance requirements is provided in the Institute of Electrical and Electronics Engineers Standard 450-1987, *IEEE Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations*. DOE facility managers should review their preventive maintenance programs for batteries and compare them to the recommendations in DOE/DP-0124T, *Emergency and Backup Power Supplies at Department of Energy Facilities*.

Facility managers should ensure that work controls are rigorous enough to prevent unplanned system impairments and to maintain facility and personnel safety during planned impairments. Personnel who track and schedule surveillances, inspections, and calibrations must ensure that any changes, such as testing frequency or personnel responsible for performing the testing, do not adversely affect equipment performance or violate facility requirements.

- DOE O 5480.22, *Technical Safety Requirements*, attachment 1, describes the purpose of surveillance requirements and states that each surveillance shall be performed within the specified interval. General principle 1 states: "A system is considered operable as long as there exists assurance that it is capable of performing its specified safety function(s)." Surveillance testing is essential for providing this assurance.

- DOE O 5480.19, *Conduct of Operations Requirements for DOE Facilities,* chapter VIII, “Control of Equipment and System Status,” states that the operations supervisor is responsible for maintaining proper configuration and for authorizing status changes to major equipment or systems. Changes in the status of facility equipment and systems should be reported to the governing stations or to the individual who authorized the change. Changes in the status of safety-related equipment and systems should be authorized by the supervisor and reported to the control area.

- DOE-HDBK-1084-95, *Primer on Lead-Acid Storage Batteries*, provides information on the operation, construction, and maintenance of lead-acid batteries. The handbook also provides information on the hazards associated with storage batteries and recommended precautions. Information on battery chargers and charging operations is provided in the maintenance section.

KEYWORDS: battery, test, inspection, compliance, explosion

FUNCTIONAL AREAS: Fire Protection, Electrical, Maintenance, Licensing/Compliance

3. ELECTRICAL ARC DURING CABLE PULLING ACTIVITY

On March 10, 1999, at the Strategic Petroleum Reserves Big Hill Site, a subcontractor electrician caused an electrical arc while pulling cables into a 480-V power distribution panel for a load center. The arc occurred when he replaced what he believed was a de-energized spare cable back into the raceway. As a result, a breaker in the power distribution panel tripped, causing an emergency generator to start. Site electricians responded to the event, shut down the emergency generator, and restored normal commercial power. The shift supervisor ordered facility personnel to stop all electrical activities in the area. The subcontractor electrician, who was wearing the appropriate personal protective equipment for pulling cable, was not injured and no equipment was damaged. To ensure positive isolation of energized circuits and minimize electrical shock hazards to personnel, job walk-downs must be conducted, lockouts and tagouts must be installed, and workers should conduct zero-energy checks before beginning work. (ORPS Report HQ--SPR-BH-1999-0003)

The site safety administrator investigated the event and found a coiled energized cable inside the power distribution panel raceway. Electricians traced the cable source to the security power distribution panel, de-energized the circuit, and disconnected the cable. A review board was convened and determined that the subcontractor electricians saw the cable in the raceway and believed it was a de-energized spare. The review board determined that although the cable was intended to supply electrical power for backup security lighting at the raw water intake structure, no one had ever connected it to the intended lighting fixture. Review board personnel believe that the cable had been in this configuration for approximately 8 years. They also determined that backup security lighting was being provided from another power distribution panel.

Subcontractor managers conducted a safety meeting with all their electrical employees to review the event. They emphasized the importance of treating all electrical cables as energized, performing zero-energy checks before beginning work, and wearing the appropriate personal protective equipment.

NFS has reported on similar procedure violations in several Weekly Summaries. Some examples follow.

- Weekly Summary 97-14 reported that decontamination and decommissioning workers at the Hanford N-Reactor cut through a conduit into an energized 220-V cable. When the workers cut the conduit and wire, they observed arcing and sparking. They bypassed hold-points required by the procedure, and the assigned electrician did not conduct a zero-energy check. Failure to follow procedures created the potential for injury and equipment damage. (ORPS Report RL--BHI-NREACTOR-1997-0006)

- Weekly Summary 97-05 reported that workers at the Hanford T-Plant Facility cut and removed a conduit and wires to an operational exhaust fan, violating facility lockout/tagout procedures. Investigators determined that no one performed a zero-energy check before beginning work. (ORPS Report RL--PHMC-TPLANT-1997-0001)

These events underscore the importance of following work plan steps and ensuring the work plan accurately reflects the necessary work requirements. Failure to do so could result in an injury or a fatality. DOE facility managers should ensure that subcontractors understand the importance of following work plans and safety rules. If the conditions found are not as expected, work should be stopped immediately and any necessary changes made to the work plan. These events also underscore the importance of writing a good work plan. Discrepancies between expected conditions and as-found conditions can result in confusion and increase the potential for errors in work plan execution. Work planners should ensure that work package drawings are correct and accurately describe the work activity. When drawings are missing or believed to be in error, facility personnel should perform thorough walk-downs to identify hazards and take extra precautions during the work activity. Once the drawings are approved, they must be controlled to prevent unauthorized alterations.

- DOE-STD-1050-93, *Guideline to Good Practices for Planning, Scheduling and Coordination of Maintenance at DOE Nuclear Facilities,* section 3.1.1.3, states that the primary objective of work planning is to identify all technical and administrative requirements for a work activity and provide the materials, tools, and support activities needed to perform the work. This would include providing accurate drawings.

- DOE-STD-1029-92, *Writers Guide for Technical Procedures*, provides guidance to assist procedure writers across the DOE complex in producing accurate, complete, and usable technical procedures that promote safe and efficient operations. This guidance can also be applied to other technical documents such as work plans. Section 2.3, “Facility Configuration,” requires walk-downs, simulations, modeling, or desktop reviews to ensure procedures are technically accurate and adequate.

KEYWORDS: procedures, work planning, raceway, electrical safety, electrical hazard, energized equipment

FUNCTIONAL AREAS: Procedures, Work Planning, Configuration Control, Electrical Maintenance

4. INADEQUATE CONFIGURATION CONTROL RESULTS IN COOLANT LEAK AT COMMERCIAL NUCLEAR PLANT

This week OEAF engineers reviewed an event at a commercial nuclear power plant in which inadequate configuration control resulted in the discharge of primary coolant from the reactor into the containment building. On December 8, 1998, plant operators were heating up the reactor and increasing pressure when a relief valve in the suction line of the residual heat removal (RHR) pumps lifted and discharged approximately 1,300 gallons of coolant from the reactor coolant system (RCS). More than a decade earlier, a modification had reduced the relief valve setpoint by 75 psig, and last year another modification changed the relief valve flow path. The operators were unaware of these modifications because procedures, drawings, and safety documentation had not been updated following the changes. The inadequate configuration control with respect to the modifications delayed the operators’ diagnosis and response to the leak. (NRC Event No. 35124 and 35127)

In 1985, maintenance personnel had reduced the relief valve setpoint from 450 psig to 375 psig. However, no one incorporated this change into the final safety analysis report or the master setpoint document. Consequently, periodic procedure reviews and simulator validations did not identify the change in the valve setpoint, and plant procedures were later revised to allow the reactor coolant pressure to be increased to 375 psig with the RHR system in service. Also, an annunciator alarm (400 psig) designed to alert operators when RHR pressure approached the original relief valve setpoint had not been revised when the relief was reset to 375 psig, so it did not alert the operators before the relief valve lifted. Because the change in the relief valve setpoint was not incorporated into plant design documents, periodic reviews of the annunciator response procedure did not identify the invalid alarm setpoint.

In 1998, maintenance personnel rerouted the discharge piping for the relief valve from the pressurizer relief tank to the containment sump to improve the accuracy of RCS leakage calculations. Although the process and instrumentation drawings were revised to reflect the new piping alignment, the simplified drawings were not revised because the cognizant engineer did not know they were controlled drawings. The new flow path was described in the RCS leakage surveillance procedure but not in the abnormal operating procedure for RCS leakage, which still indicated that the relief valve discharged to the pressurizer relief tank. Operations personnel failed to describe the new flow path in the latter document because they did not realize that the abnormal operating procedure would be affected by the modification.

NFS has reported inadequate configuration control events in the Weekly Summary. Some examples follow.

- Weekly Summary 99-01 reported that a gasket between an access manway and the column flange on a 500,000-gallon elevated water storage tank at the Pantex

Plant blew out, spraying water approximately 30 feet. Crafts personnel were removing the manway in order to locate and repair a water leak. They had removed 80 percent of the bolts holding the manway in place when the gasket blew out. Crafts personnel believed the manway allowed access into a dry area beneath the tank. However, the tank was configured with a wet column or riser rather than a dry one. Plant personnel did not know the design configuration of the tank. (ORPS Report ALO-AO-MHSM-PANTEX-1998-0093)

- Weekly Summary 96-47 reported that engineers at the Rocky Flats Environmental Technology Site discovered undocumented modifications that obstructed ventilation flow paths between rooms. The obstruction affected the reading of differential pressures between the rooms on differential-indicating controllers, as required by the building operational safety requirement. Investigators determined that workers had covered up a door with drywall and that the door had ventilation louvers to allow air to flow between rooms. (ORPS Report RFO--KHLL-771OPS-1996-0179)

- Weekly Summary 96-37 reported that a cooling tower water relief valve lifted at the Rocky Flats Environmental Technology Site, flooding five subbasement rooms with 4,600 gallons of water. The relief valve lifted when operators started a cooling tower water pump. Investigators determined that inadequate configuration control contributed to this event in two ways. First, facility personnel did not consider the impact of the cooling tower water system relief valve on the subbasement of the building. Second, the relief valve that lifted had not been tested, and data did not exist to allow determining either the design setpoint or the test setpoint until engineers conducted a detailed review of the equipment. (ORPS Report RFO--KHLL-371OPS-1996-0110)

These events illustrate the importance of ensuring that facility modifications are properly reflected in safety documentation, procedures, and drawings. Modifications should be addressed in training programs for operators, technicians, and maintenance personnel. Configuration control is an important part of facility safety. Controlled documents must be accurate and continually updated to reflect actual facility conditions. Facility managers should review the following documents to ensure that management policies and procedures exist that address proper configuration controls.

- DOE O 5480.19, *Conduct of Operations Requirements for DOE Facilities*, chapter VIII, “Control of Equipment and System Status,” states that managers of DOE facilities shall establish administrative control programs to handle configuration changes resulting from maintenance, modifications, and testing.

- DOE-STD-1073-93-Pt.1 and -Pt.2, *Guide for Operational Configuration Management Program Including the Adjunct Programs of Design Reconstitution and Material Condition and Aging Management*, discusses the control of modifications that can lead to temporary or permanent changes in design requirements, facility configuration, or facility documentation. The standard discusses identifying changes, conducting technical and management reviews, and implementing and documenting changes.

KEYWORDS: configuration control, documentation, drawings, modification control, procedure

FUNCTIONAL AREAS: Configuration Control

5. PROPANE CYLINDER LEAK AT OAK RIDGE

On March 15, 1999, at the Oak Ridge East Tennessee Technology Park, Property and Materials Management personnel reported to facility supervision that a 150-lb propane cylinder was leaking in a covered but open storage shed. Site protective forces blocked the streets around the storage shed, all personnel in the area were evacuated, and the site fire department responded to the scene. A hazardous materials response team stopped the leak, using leak-patching equipment to seal the cylinder valve and valve cap. After the leak was stopped, the cylinder was moved to a safe location. This event is significant because it had the potential for serious personnel injury and facility damage from the uncontrolled release of a flammable gas. (ORPS Report ORO--BJC-K25GENLAN-1999-0005)

Investigators determined that the valve on the cylinder had been damaged when the Property and Materials Management personnel attempted to loosen the cylinder valve cap. The valve cap was tightened beyond hand-tight and the workers tried to loosen it by inserting a lever through the cap ports. This damaged the valve, allowing the uncontrolled release of propane from the cylinder.

NFS has reported other events in the Weekly Summary involving the improper handling of compressed gas cylinders. Some examples follow.

- Weekly Summary 99-02 reported that two firefighters at the Brookhaven National Laboratory were slightly injured when one of them accidentally discharged an 800-psi carbon dioxide cylinder. The cylinder spun out of control and struck one of the firefighters on the calf, inflicting a deep-muscle bruise. The other firefighter fell as he was trying to avoid the cylinder and experienced a scraped elbow and knee. One of the firefighters was transported to a local hospital and the other was treated at the site clinic. Both returned to work the same day. The facility manager stood down further work on the cylinders and directed the safety engineering group to conduct an investigation. (ORPS Report CH-BH-BNL-BNL-1998-0041)

- Weekly Summary 96-26 reported two events in which compressed gas cylinders were dropped, creating a hazard to personnel. At the Oak Ridge National Laboratory, a compressed gas cylinder rolled down a flight of stairs, injuring a pipe fitter and damaging the cylinder. At the Rocky Flats Environmental Technical Site, a cylinder that supplied breathing air to the cab of a front-end loader fell off the vehicle when the lower support bracket failed during soil removal operations, causing an air-off condition in the cab. In both cases, improper handling of compressed gas cylinders created the potential for serious injury and equipment damage. (ORPS Report ORO--LMES-X10PLEQUIP-1996-0001 and RFO--KHLL-ENVOPS-1996-0006)

OEAF engineers also reviewed an event at the Oak Ridge Y-12 Site in which a cylinder became a missile. On September 20, 1995, a 100-lb-capacity carbon dioxide cylinder discharged its contents and became airborne after firemen incorrectly manipulated a discharge-valve, hand-lever attachment. The cylinder, propelled by its high-energy contents, narrowly missed the firemen as it traveled 30 feet across a parking lot and struck a concrete ramp. (ORPS Report ORO--MMES-Y12SITE-1995-0025)

The Computerized Accident Information Reporting System (CAIRS) database lists 194 accidents involving compressed gas cylinders over the last 11 years. Although there has been an overall downward trend in the number of accidents attributable to compressed gas cylinders since 1990, the number of accidents remains significant, pointing to a continuing need for an awareness of and adherence to compressed gas cylinder safety requirements.

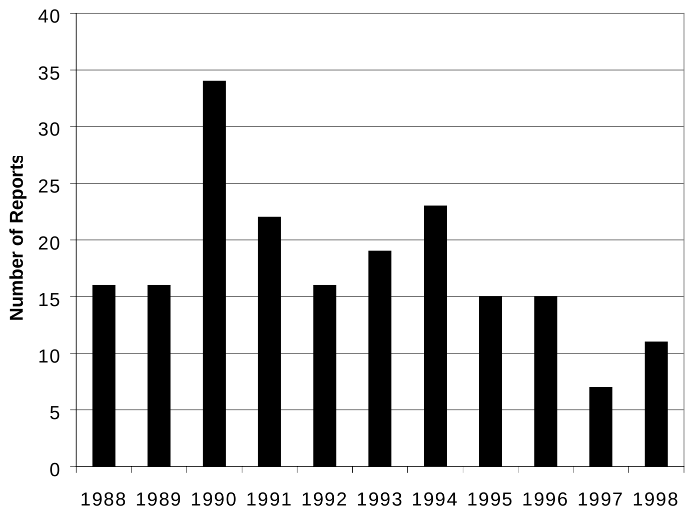

Figure 5-1. Compressed Gas Cylinder Accidents[1]

These events emphasize the need to exercise extreme care when handling compressed gas cylinders. Compressed gas cylinders can be large, heavy, and difficult to handle and can cause serious personnel injury. They should be properly secured at all times to prevent tipping, falling, or rolling. They can be secured with straps or chains connected to a wall bracket or other fixed surface, or by use of a cylinder stand. Cylinders should be stored in an area where they will not be knocked over or damaged by falling objects. When a cylinder is not being used, the valve should be closed and the valve cap secured hand-tight. When a valve cap is being installed, it should not be spun; it should be rotated slowly until seated. A torque device should not be used to tighten a valve cap. To avoid damaging or accidentally opening a cylinder valve, there should be no attempt to remove a stuck or jammed valve cap using a leverage device through the cap. With the cylinder firmly secured, a noninvasive device such as a strap wrench should be used to loosen the cap, or a tag or label identifying the problem should be attached to the cylinder and the cylinder returned to the supplier.

Managers at DOE facilities should ensure that compressed gas cylinder safety is an integral part of the facility safety program. NFS has issued Safety Notice DOE/EH-0527, Compressed Gas Cylinder Safety, which contains summaries, corrective actions, lessons learned, recommendations related to compressed gas cylinder events, and additional references. Safety Notices are available at http://tis.eh.doe.gov/web/oeaf/lessons_learned/ons/ons.html.

The requirements of 29 CFR 1910.101, “Compressed Gases,” state that the in-plant handling, storage, and use of compressed gases in cylinders shall comply with Compressed Gas Association Pamphlet CGA P-1, *Safe Handling of Compressed Gases*. Pamphlet CGA P-1 costs $78.00 for nonmembers of the Compressed Gas Association ($43.00 for members). It can be ordered in any of the following ways.

- Call (703) 412-0900, extension 799, between 0900 and 1630 EST.

1 OEAF engineers searched the CAIRS database for Accident Source Code 1306 (Compressed Gas Cylinder) from 1/1/88 through 12/31/98.

- Fax the order and a credit card number to (703) 412-0128. Only MasterCard™ and VISA™ are accepted. If a purchase order is submitted, there is an additional $15.00 fee.

- Mail a prepaid order to CGA Publications, 1725 Jefferson Davis Highway, Suite 1004, Arlington, VA 22202-4102

KEYWORDS: compressed gas, cylinder

FUNCTIONAL AREAS: Industrial Safety, Material Handling/Storage